

# OREGON STATE UNIVERSITY

SCHOOL OF AGRICULTURE and AGRICULTURAL EXPERIMENT STATION

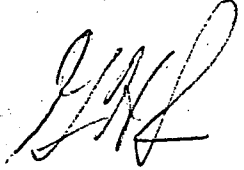
Reply to: DEPARTMENT OF SOILS

E7.3 10579  
CR-131883  
CORVALLIS, OREGON 97331

May 10, 1972

## MEMORANDUM

TO: Mr. Edward W. Crump, Technical Officer

FROM: Gerald H. Simonson, U-619, Oregon State University 

SUBJECT: Progress report for period ending April 30, 1973, of SR-345, "Comparative Evaluation of ERTS Imagery for Resource Inventory in Land-Use Planning."

### Overall Objectives:

1. Use a multi-discipline team approach to determine features that can be successfully monitored by ERTS-A imagery for resource inventory, planning, land-use zoning and resource development.
2. Using carefully selected sample areas, develop a comprehensive resource inventory mapping system for use in planning, zoning, and resource development.

Progress during this reporting period included image interpretation and evaluation on a quick-look basis and filing of image descriptor forms for state-wide coverage; mapping of geology, soils and range resources on 1:250,000 scale enlargements of band 5, and 1:120,000 scale color IR U-2 aircraft support highlight imagery; geologic interpretation of gray scale printouts of digital data; analysis of tectonic systems of portions of Eastern Oregon with ERTS imagery; computer formatting and preliminary analysis of selected frames; developing algorithms and signature identification of several resource features in portions of Crook County; detailed vegetation mapping on sample plots for ground truth; field checking of soil mapping unit composition for ground truth correlation; comparative interpretation of ERTS and highlight imagery in multi-stage timber inventory experiments; and work with local users in Crook County on applications of the information.

### Current Problems:

1. We are continuing to have problems with the ordering and shipping of computer tapes. Appendix I gives the scenes (digital) ordered (MSS bulk, 7 track) and their status. The scenes marked with asterisks are over our primary test site. We have yet to obtain complete coverage of this area and have been working only with those areas that are overlaps from adjacent scenes.

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(E73-10579) COMPARATIVE EVALUATION OF  
ERTS IMAGERY FOR RESOURCE INVENTORY IN  
LAND USE PLANNING Progress Report,  
period ending 30 Apr. 1973 (Oregon State  
Univ.) 10 p HC \$3.00

2. There appear to be repeating patterns of lower or higher values in some of the digital imagery received. The problem of every sixth scan line in band four being in error still occurs, but to a lesser degree than previously. The patterns in the other bands appear at the low end of the intensity scale (little reflection) and do not appear to present a serious problem at this time but should be noted and kept in mind.
3. Due to lack of cloud-free imagery for 1973, interpretation is continuing with the best scenes obtained from the 1972 growing season.

#### Multi-discipline Resource Inventory of Soils, Vegetation and Geology:

Mapping of ground truth on NASA highflight photography of Crook County, Oregon, has been completed for vegetation and land-use and is approximately 20 percent complete for geology and soils. Geology, soils and macrorelief maps have been approximately 75 percent completed on ERTS-1 imagery, at a scale of 1:250,000. The more detailed maps will be used to test and revise those made from satellite imagery in addition to providing county and regional planners with an information base at a larger scale.

Several meetings have been held with officials concerned with land-use planning in Crook County and environs to evaluate current needs and define priorities for the near future.

#### Range Resources:

Work in the last two months has been directed toward accomplishment of Specific Objective 1: Development of a ground truth base for comparison of ERTS-1 data. Tasks completed include our filing system for ground truth data and mapping of the vegetation-land use of Crook County on the highflight imagery at 1:120,000 (color IR, NASA flight 72-114, 16 July). A mosaic, in black and white, of Crook County has been made from the same imagery (at 1:120,000) and copies of this have been placed in Crook County for local use.

Work on the vegetation-land use part of the integrated land resources technical legend has been virtually completed to tertiary level. A few classes need finalizing and the descriptive legend will be complete. In cooperation with Geology, work on the geomorphic part of the legend is progressing.

Using 1:30,000 color infrared imagery of Big Summit Prairie (Crook County, Oregon) the vegetation occurring on the prairie and surrounding forest fringes was mapped in detail. Ground truth samples were run to determine actual make-up of mapping units and to check boundary accuracy. Sample plots were established to facilitate computer mapping of the prairie and surrounding forests and scablands.

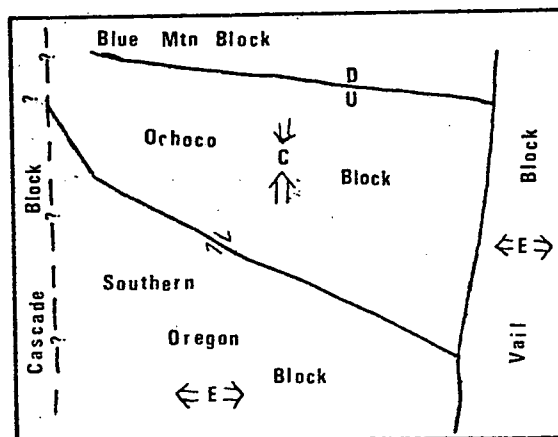
The resulting information will be correlated with soils and geologic mapping to enable county planners to assess the area in terms of proposed residential development sites.

## Geology:

Geologic study of the Big Summit Prairie area using the digital output of frame #1021-18151-5,6,7 was completed using programs prepared by the OSU computer center portion of the project. Grayscale printouts of the data using 3 to 9 density classes were made. Numerous significant features are revealed in greater detail than on any photographic product. These include patterns of major drainage ways, landslide blocks, patterns of joint development, at least one large fault, and important details within the bottomlands, that are probably vegetational differences related to subsurface distinctions. Of these the joint pattern is best displayed on band 5, while the landslide blocks are well shown on band 7. The latter are deeply shadowed and virtually indistinguishable on band 5. Examples are attached (Appendix III). The detail in the bottomlands is valuable. It is greater than is shown elsewhere, short of the highlight imagery, and the distinctions that are made are not shown on any existing geologic mapping.

The tectonic mapping work previously discussed has resulted in some new ideas about the tectonic framework of central Oregon in the area centered on Crook County. As shown on Figure 1, regional tectonic blocks bounded by major structures can be outlined for the area. Within each block the recent tectonic history has been nearly constant. The Southern Oregon block is the northern end of the basin/range province and has been undergoing east-west extension, probably with some superposed right lateral shear. Its northern boundary is the Brothers Fault Zone in which the pattern of en echelon shears indicates right lateral motion. In the Ochoco block north of this zone the recent past has involved folding and north-south tilting. Some of the folding is on east-west axes and some is on north-south axes. In general the region shows shortening in all directions. Its northern boundary is the Ochoco Fault, downthrown on the northern side. The Brothers Fault Zone ends abruptly at the Steens Mountain Fault where the region of east-west extension extends on to the north as the Vail block. To the west it appears to end at the Cascades, although some workers believe that it extends through the range. If so, it would appear that the continuing features are essentially splays of the major fault zone. From this tectonic framework one can suggest an interpretation of the cause of the motion of the Brothers Fault Zone that improves on past approaches.

Figure 1.



This is to suggest that the internal deformation of the Ochoco and Southern Oregon blocks inevitably produces the motion seen. That is, north of the zone the Ochoco block is either stable in an east-west sense or is being shortened slightly in this direction, while south of the zone the Southern Oregon block is being considerably extended. The intervening motion follows immediately. Further, it follows that the offset on the Brothers Zone is not very large during the time for which this regime has obtained. One could indeed roughly determine it from an estimate of the internal deformation of the two neighboring blocks.

#### Forestry:

The major emphasis during the last reporting period has been interpretation work on the multistage sampling inventory of the Ochoco National Forest in Crook County, Oregon. Statistical comparison between estimates of percent crown closure made on 100 randomly located plots taken from NASA-Ames highlight photography and the five timber density classes separated on ERTS-1 imagery revealed that the latter procedure resulted in only a slight gain in sampling efficiency.

Percent crown closure interpretation of the 100 randomly located plots on the NASA-Ames 1:120,000 highlight photo coverage has been completed by three interpreters. These results are shown in Table 1, Appendix II. Statistical analysis of these results in regard to the benefits of stratification into timber density classes on ERTS-1 imagery has been completed and is discussed below.

In the initial phases of this research, it was believed that stratification of timber density classes from ERTS-1 imagery was both feasible and beneficial. The results of this stratification have been previously reported and summarized in the six-month report. For any stratification to be beneficial to the resource there must be a reduction in the sampling error (standard error of the mean expressed as a percent of the mean) among stratified plots as compared to non-stratified plots. The separation of forested versus non-forested lands, which is easily accomplished with ERTS-1 imagery, is not considered beneficial in most parts of the United States (including the Ochoco National Forest), since the location of forested versus non-forested lands has been previously documented. To determine the statistical gain in efficiency resulting from stratification the following analysis was conducted using the interpretation results from three experienced interpreters. To form a basis for comparison, the 100 plots were considered to form a random selection from a non-stratified population. The average standard error of the mean as a percentage of the mean was calculated to be 6.53%.

The next step was to calculate the same statistic for the stratified population using the five timber density strata previously discussed. The resultant average standard error of the mean as a percentage of the mean was calculated to be 6.19%. This gave an average resultant gain in efficiency of only 5.25%. Although this is a gain over the non-stratified population, its significance is questionable. Therefore, it was necessary to reconsider the basic premise of stratification from ERTS-1

imagery. Based on a statistical analysis of the initial stratification, it appeared that we attempted stratification into too many classes and that combining certain strata might prove to be more efficient. Table 2, Appendix II, shows the results of several groupings of strata and their resultant gains in efficiency.

These results clearly demonstrate that the use of two strata provides the largest gain in efficiency over the non-stratified population. Further investigation of these strata by interpretation of NASA-Ames 1:30,000 highflight imagery demonstrates that this combination of strata results in classification of forest lands into non-stocked and stocked forest lands.

The question arises then: "What was wrong in the original five strata determined from ERTS-1 imagery?" Preliminary analysis and review indicate that two major factors influenced this problem of stratification. The first factor is that of shadow. With a 10 o'clock sun angle, north-facing slopes are in shadow and therefore appear anomalously dark on the color-enhanced imagery. The knowledge that denser forests of the region on north-facing slopes causes the interpreter to overinterpret the dark tones seen on the color-enhanced imagery. This error is magnified even more when only the black or white MSS-5 imagery is interpreted.

The second factor contributing to error is the lack of tonal signature distinction between forest species and brush species in this region. Because of the lack of height definition on ERTS-1 imagery, tonal signature becomes the critical defining characteristic of vegetation. Although little difficulty has been found in separating grasslands from forest lands, separation within the forest lands of trees and brush presents severe difficulties. This problem requires further investigation in the use of color enhancement and different seasonal imagery and will be investigated further.

Other research during this reporting period has included continuing coordination with the Electrical Engineering Department on computer recognition and analysis of forest insect damage and coordination with John Wear of the USFS Region 6 on the identification of forest diseases and insects from ERTS-1 imagery.

Modification of the OSU color enhancer has been completed to allow better illumination of the subject images. Modification of the transparency mounts to allow 15° of swing about the center axis has also been completed, which reduces the registration time required for use.

#### Computer Center:

Several revisions have been made to the computer program for reformatting and packing original NASA data into a CDC 3300 compatible form. These modifications provide an improved identification record for the output files and make the program shorter and less costly. Further program changes are planned including rewriting some program sections into

machine code for improved execution times. Work is continuing on improving and developing new features in our interactive selection and formatting programs.

We have provided technical assistance and copies of digital imagery to the concurrent investigation in Electrical Engineering. Selected copies of digital imagery have been provided to the Computer Center's graphics display group for use on a light-pen equipped CRT attached to a PDP-8. This work is being done on a no-cost basis, and while not considered a part of the ERTS project, will contribute to the interactive display and selection of digital imagery.

We have been requested to furnish a description and some of our impressions of ERTS data, particularly digital imagery, to the Biology Discipline Committee on CONDUIT, an NSF sponsored study for the dissemination and implementation of computer materials in instructional use at the university level. (The five cooperating members of CONDUIT are Oregon State University, University of North Carolina, Dartmouth, University of Iowa, and the University of Texas.) We are in the process of supplying the requested information.

#### Electrical Engineering:

PIXEL has been active in determining signatures and developing algorithms for the classification of natural resources. Thus, considerable success has been achieved in developing techniques suitable for seasonal monitoring of water acreage. A summary of these activities and accomplishments is currently being prepared.

We are currently working closely with other members of the interdisciplinary team on the resource mapping of Big Summit Prairie in Central Oregon. We hope to be able to determine acreage and vigor of natural meadows and rangeland. Automatic classification agrees quite closely with available ground truth.

Our efforts to develop spectral signatures for forests infected with Tussock Moth is currently stalled pending more accurate location of training sets for use in the classification algorithm.

1. "Computer Processing of Earth Resources Data From the ERTS-1 Satellite," Oregon State University Engineer, March, 1973.
2. "Comparative Evaluation of Spatial Features in Automatic Land Use Classification From Photographic Imagery." Submitted to "Conference on Machine Processing of Remotely Sensed Data," Purdue University.

#### Work Planned for Next Period:

Emphasis will be placed on early completion of preliminary resource and land use for Crook County, developing interpretive information about suitability for different uses, and working with the local planners in evaluation and effective use of the ERTS and highlight imagery and derived information.

Significant Results:

The following results of particular significance can be listed for this reporting period:

Numerous previously unmapped faults in central Oregon have been Distinguished on ERTS-1 imagery. Of particular significance are those found in the rather uniform lithologies of the Clarno and John Day Formations.

Tectonic mapping of fault-controlled linears demonstrates the utility of ERTS imagery as a means of illustrating and studying the regional tectonics of the state, especially in the recent past. Probable strain patterns have been suggested.

Digital output from frame #1021-18151 has shown the enhanced ability to interpret such features as joint patterns, shadowed landslide blocks, bottomlands, and drainage patterns. Greater detail is available in every case than is possible using photographic products.

Soil colors observed on ERTS frame #1075-18150-5 at the eastern end of the Columbia basin correlate very well with those from descriptions of soils from that area.

Widespread use of a wheat-fallow rotation in northern Umatilla County, Oregon, insures that nearly one half of the cultivated soil is devoid of vegetation much of the time. In early fall, stubble of harvested wheat fields provides a nearly uniform and light-toned background against which the color of dry-fallow fields can be compared. Along a 30-mile transect, extending from Echo, in the west to Weston in the east, color of dry surface soils gradually changes from light brownish gray (Sagehill, Sagemoor, and Taunton soil series) to dark grayish brown (Athena, Palouse, and Waha soil series). On ERTS imagery, fallow fields are only slightly darker than fields of wheat stubble at the western end of the transect. At the eastern end of this transect, fallow fields are much darker than stubble fields, which results in a high-contrast, checker-board pattern.

Similar climate-related contrasts in soil color are visible on ERTS imagery from several other portions of the Columbia Basin. Absence of steep topography in the area mentioned above, however, minimizes the disturbing effect caused by shadows.

GHS:al

cc: ERTS Contracting Officer, Code 245  
ERTS Project Scientist, Cosde 650  
ERTS Scientific Monitor  
J. H. Boeckel, Code 430

Appendix I

<u>Scenes</u>	<u>Date Ordered</u>	<u>Date Received</u>	<u>Comments</u>
1004-18210*	9-28-72		Never received; master tape reportedly damaged; order finally cancelled.
1021-18151	9-28-72	11-13-72a 11-29-72b 1-3-73c	a) First copy received was in 9-track format, not 7. b) Second copy has an error in every sixth scan line in band four; a corrected copy is now being processed. c) An additional copy of this scene was received without being ordered.
1041-18262	12-11-72	5-1-73	It was necessary to make three telephone calls to run this missing scene down.
1041-18265	12-11-72	1-30-73	Irrecoverable parity errors in identification and annotation records.
1021-18145	12-22-72	1-30-73	No errors.
1076-18211*	2-7-73	3-27-73	Received as 9 channel rather than 7; have been reordered.
1041-18210*	2-7-73	3-27-73	
1076-18213	4-9-73	5-4-73	No apparent errors.
1004-18212	4-9-73		Not received yet.
1006-18315	4-20-73		Not received yet.
1006-18322	4-20-73		Not received yet.

Appendix II

Table 1. Photo Interpretation Results from 1:120,000 NASA-Ames High-flight Photogrammetry.

Density Class	Statistic	Interpreters			Average
		A	B	C	
I	$\bar{x}$	13.0500	10.250	7.7000	10.3333
	s	14.9225	11.7063	10.5536	12.3941
	cv	1.1435	1.1421	1.3706	1.2187
	$s_{\bar{x}}$	3.3367	2.6176	2.3598	2.7714
II	$\bar{x}$	36.0000	27.0000	23.7500	28.9167
	s	15.1830	11.4017	14.1305	13.5717
	cv	0.4218	0.4223	0.5950	0.4979
	$s_{\bar{x}}$	3.3950	2.5494	3.1596	3.0347
III	$\bar{x}$	49.7500	42.7500	39.7500	44.0833
	s	19.8994	16.7390	21.7325	19.4570
	cv	0.4000	0.3916	0.5467	0.4461
	$s_{\bar{x}}$	4.4496	3.7429	4.8595	4.3507
IV	$\bar{x}$	60.5000	55.2500	59.0000	58.2500
	s	20.7681	18.3155	18.8204	19.3013
	cv	0.3433	0.3315	0.3190	0.3313
	$s_{\bar{x}}$	4.6438	4.0954	4.2083	4.3158
V	$\bar{x}$	52.7500	53.0000	50.4000	52.0500
	s	19.2268	25.2044	28.6822	24.3711
	cv	0.3645	0.4756	0.5691	0.4697
	$s_{\bar{x}}$	4.2992	5.6358	6.4135	5.4495

Table 2. Grouping of Strata and Resultant Gains in Efficiency.

Strata Grouping	Interpreter						Average	
	A		B		C		$S_{\text{yst}}$	Gain
	$S_{\text{yst}}$	Gain	$S_{\text{yst}}$	Gain	$S_{\text{yst}}$	Gain		
Non stratified	6.36%	-	6.27%	-	6.97%	-	6.53%	-
Five strata	6.42%	- 0.94%	5.35%	14.67%	6.81%	2.30%	6.19%	5.20%
3 Combined strata (1,2), (3,4), 5	5.94%	6.60%	5.10%	18.66%	6.04%	13.34%	5.69%	12.68%
3 Combined strata (1,2), 3, (4,5)	7.94%	-24.83%	6.94%	-10.69%	8.35%	-19.8%	7.74%	-18.47%
2 Combined strata (1,2), (3,4,5)	5.15%	19.03%	4.94%	21.21%	5.68%	18.51%	5.26%	19.54%



Landslide Blocks on computer output of  
Band 7, 13 August 1972  
Frame 1021-18151



Joint Pattern on computer output  
of Band 5, 13 August 1972  
Frame 1021-18151

Examples of Computer Grayscale Results